Aswan University Journal of Science and Technology Volume 5, issue 1, March 2025

Effect of spraying potassium and amino acids on the productivity of Barhee Date palm

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Abstract

The present study was carried out during 2020 and 2021 seasons on 20 years old Barhee date palm (*Phoenix dactylifera* L.) grown in Agricultural research station farm that located at Kom-Ombo, Aswan Governorate, Egypt. The objective of the study is to investigate the promotive effect of spraying Barhee date palm bunches with potassium silicate and amino acids on yield and fruit physical and chemical characteristics. Bunches were sprayed with potassium silicate at 0.50 or 1% and amino acid at 2 or 4% thrice at 4, 7 and 10 weeks of pollination. Spraying treatments were performed as potassium silicate or amino acid alone or combination of them, beside the control treatment (spraying with water only). Results indicated that all spraying treatments significantly increased yield and improved fruit physical and chemical characteristics as compared with untreated palms. Spraying bunches with potassium silicate at 0.5 or 1% singly or combined with amino acid at 2% were more effective treatments in increasing yield and improving physical and chemical properties of fruits. In addition, it minimized the harmful heat stress effects.

Keywords: Date palm; fruit yield; fruit quality; potassium citrate; amino acid.

Introduction

Date palm (*Phoenix dactylifera* L.) has long been one of the most important fruit crops grown in semiarid and arid- regions. In Egypt, many farmers rely on date palms cultivation and exportation of their fruit. According to **[1].** Egypt is considered the leading country among the top ten date producers (1,130,000 tons). 'Barhee' is one of the most commercial and soft fruit cultivars in Egypt. Fruit trees are seriously impacted by climatic variable. Due to changing climatic conditions, the fruit trees are facing many challenges regarding their productivity **[2].**

The anticipated climate changes and increasing CO_2 levels with global warming can result in greater changes of yield and fruit quality. Fruiting is directly influenced by climatic factors i.e. high temperature, low soil moisture and high evaporative. So, under changing climate, the management of natural resources like nutrients and water are a possible solution **[3].** Moreover, major problems face date growers as low annually average of yield and fruit quality.

Minerals element especially silicon and potassium have an important role for increasing yield and fruit quality. It increases the tolerance of trees for many stresses, therefore determination the optimum levels for them is a necessity for date palm fertilization. Foliar application of macro and amino acids is the key to improve the productivity and quality of fruits trees, as well as it has a beneficial role in reclamation of nutritional and physiological deficiency in fruit trees **[4, 5, 6].**

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Received March 14, 2024, received in revised form, May 07, 2024, accepted May 07, 2024.

Potassium is very important for main physiological functions, such as sugars and starch formation, proteins synthesis and meristematic tissues development. It activates many different enzymes involved in cell division, growth, fruit formation and could improve fruit size, flavor and color **[7, 8].** In addition, it has been shown to promote plant disease reduction, and potassium stress can increase the degree of crop damage by bacterial and fungal diseases **[9].** Potassium silicate is a source of highly soluble potassium and silicon. It is used in agricultural production systems primarily as a silica amendment and has the added benefit of supplying small amounts of potassium **[10, 11].** Previous studies emphasized the benefits of potassium on fruiting of palm dates **[11, 12, 13, 14, 15, 16, 17, 18, 19].**

Antioxidants such as amino acids, citric acid, ascorbic acid, and vitamins have synergistic effect on growth and productivity for most of fruit trees and may play a definite role on solving the problem of poor yield, through enhancing growth nutritional status, yield, and fruit quality in different fruit trees **[6, 20, 21].** Amino acids defensive role against oxidative stress, cell senescence, fungal attack, as well as enhancing cell division and growth. Furthermore, they improve flowering and fruit setting particularly under stressful conditions **[22, 23]**. The demand of essential amino acids is well recognized as an application to boost yield and fruit quality. The implementation of amino acids for foliar use is based on the necessity of crops in general and at critical development stages in specific. Many studies have shown the assured role of amino acids on increasing the yield and improving fruit quality **[2, 6, 19, 23].**

So, the present study was planned to know the response of foliar application of potassium citrate and amino acids on yield and fruit quality of Barhee date palm.

Materials and Methods

The present study was carried out during 2020 and 2021 seasons on 20 years old Barhee date palm (*Phoenix dactylifera* L.) grown in Agricultural research station farm that located at Kom Ombo, Aswan Governorate, Egypt. The texture of soil is silty clay and analysis of it was done according to **[24].** and the obtained data are given in Table (1). The selected palms were healthy, nearly uniform in growth vigor and fruiting and received regular horticultural practices. In addition, pruning was performed to maintain bunch/mature leaves ratio to 1:8, respectively. The number of spathes per palm was edited to 12 bunches by removing excess earliest, latest and smallest inflorescence. Pollination was carried out using the same pollen grain source during both seasons of the study.

Table (1): Mechanical, physical and chemical analysis of the tested orchard soil.

Characters	Values	Characters	Values
Particle size distribution		P (ppm Olsen method)	20.00
Sand %	10.60	K (ppm ammonium acetate)	419.00
Silt %	58.00	Mg (ppm	79.00
Clay %	31.40	S (ppm)	6.90
Texture grade	Silty clay	B (ppm hot water extractable)	0.27
pH (1:2.5 extract)	8.00	EDTA extractable micronutrients (ppm)	
E.c (1:2.5 extract) mmhos/1cm/25°C	0.91	Zn	1.31
Organic matter %	2.09	Fe	11.00
$CaCO_3$ %	1.22	Mn	10.18
Macronutrients values		Cu	1.60
Total N%	0.11		

Five date palms were selected and divided into six treatments in five replicates (each replicate as two bunches) and arranged in a randomized complete block design as follows:

1-Control treatment (sprayed with water only).

2-Spraying bunches with potassium silicate at 0.50%.

3- Spraying bunches with potassium silicate at 1%.

4- Spraying bunches with 2% amino acids.

5- Spraying bunches with 4% amino acids.

6- Spraying bunches with 0.50% potassium silicate and 2% amino acids.

All spray treatments were thoroughly applied on bunches using hand sprayer (5 liters capacity). Potassium silicate or amino acid was sprayed after four, seven and ten weeks of pollination. The response of "Barhee" date palms to potassium silicate or amino acids, and their combinations were evaluated through the following determinations:

Yield components as, fruit retention, bunch weight and yield/palm

The fruit retained percentage were calculated at harvest. Five inner and outer strands per bunch after harvest time. The percentage of fruit retention were calculated using the following equation:

$$Fruit\ retention\ \% = \frac{Total\ number\ of\ retained\ fruits\ strand}{Number\ of\ retained\ fruits\ /\ strand\ and\ flowersno.flower\ scars}\ x\ 100$$

Bunches were harvested at the first of August when the fruits reached Khalal stage. The average yield weight/palm and bunch weight were recorded in kilograms.

Fruit physical characteristics:

At the peak of color, fruit were picked at random from each bunch to determine physical properties such as fruit weight (g), fruit dimensions (cm) (Length and diameter), pulp weight (g) and flesh %.

Fruit chemical characteristics:

Chemical properties i.e. total soluble solids content (T.S.S.) % was determined using hand refractometer, also percentage of total acidity as gm citric acid/100gm fruit weight and total tannins. Reducing sugars %, non-reducing sugars % and total sugars % were determined according to **[25].**

Statistical analysis:

The obtained data during two studied seasons were subjected to analysis of variance according to **[26].** Means were differentiated using values of new LSD at 5% level.

Results

1- Yield components:

Data in Table (2) showed that the effect of potassium silicate and amino acids on yield components of Barhee date palm during 2020 and 2021 seasons. It is obvious from the data that results took similar trend during the two studied seasons.

Results indicate that yield components i.e. fruit retention, bunch weight and yield kg/palm significantly increased due to potassium or amino acids spraying by different concentration as compared to unsprayed ones (control). It could be noticed that, all spraying treatments significantly increased fruit retention as compared with unsprayed ones (control). In this respect, the best treatment that gave the highest significant fruit retention (37.43 & 37.85% as an av. of the two studied seasons) due to 1% potassium silicate (T3) or 0.5% potassium silicate plus 2% amino acid (T6) followed by 0.50% potassium silicate (T2) as an av. of the two studied seasons. Control palms gave the lowest significant fruit retention, where it recorded (34.00% as an av. of the two studied seasons). No significant differences were found due to spray potassium alone or potassium plus amino acids. So, in general economic view, it concluded that to spray potassium silicate alone or in combination amino acids at lower concentration.

Concerning bunch weight, results in the same table reveal that, all amino acid and potassium silicate singly or in combinations had a positive effect on bunch weight as compared with the control. Amino acid at 2% plus, 0.5% potassium silicate as well as 0.5 or 1% potassium silicate gave the highest bunch weight (15.49, 15.00 and 15.27) followed by amino acid 2 or 4% (13.32 & 13.67 kg as an av. of the two studied seasons). On the other hand, control treatment recorded the lowest bunch weight (12.14 kg as an av. of the two studied seasons). The recorded bunch weight was (12.14, 15.00, 15.27, 13.32, 13.67 & 15.49 kg as an av. of the two studied seasons) due to T1 to T6, respectively. Then, the corresponding increment percentage of bunch weight due to treatments over untreated ones attained (23.56, 25.78, 9.72, 12.60 & 27.59%), respectively.

Moreover, 2% amino acid plus 0.5% potassium silicate recorded the maximum yield per palm since it was 185.9 kg/palm as av. of the two studied seasons, followed by potassium silicate at 0.5 or 1% which recorded 180.00 & 183.3 as av. of the two studied seasons, respectively. Meanwhile, control treatment recorded the lowest value in this respect, since it was 146.0 kg as an av. two studied season. On the other hand, the other treatments were in between range. Hence, the increment percentage of yield/palm attained (23.27, 25.55, 9.32. 12.33 & 27.33% as av. of the two studied seasons) due to spray bunches with 0.5% potassium silicate (T2), 1% potassium silicate (T3), 2% amino acid (T4), 4% amino silicate (T5) and 0.5% potassium silicate plus 2% amino acid (T6) compared unsprayed ones (control, T1), respectively.

Table (2): Effect of potassium and amino acid spraying on fruit retention (%), bunch weight (k) and Yield/palm (kg) of Barhee date palm during 2020 and 2021 seasons.

Charac. / Treat.	Fruit retention (%)			Bunch weight (k)			Yield/palm (kg)		
	2020	2021	Mean	2020	2021	Mean	2020	2021	Mean
T1	32.19C	35.80C	**34.00C**	10.43C	13.84C	**12.14C**	125.2C	166.7C	**146.0C**
T2	35.22A	38.91A	**37.07A**	12.90A	17.10A	**15.00A**	154.8A	205.2A	**180.0A**
T3	35.68A	39.18A	**37.43A**	13.19A	17.35A	**15.27A**	158.3A	208.2A	**183.3A**
T4	33.86B	37.64B	**35.75B**	11.45B	15.18B	**13.32B**	137.4B	181.8B	**159.6B**
T5	34.10B	37.76B	**35.93B**	11.72B	15.62B	**13.67B**	140.6B	187.4B	**164.0B**
T6	36.05A	39.64A	**37.85A**	13.47A	17.51A	**15.49A**	161.6A	210.1A	**185.9A**
New LSD	**1.49**	**1.67**	**1.13**	**0.65**	**0.88**	**0.55**	**8.97**	**10.31**	**6.88**

T_1- Control (water spray), T_2- 0.5% potassium silicate. T_3- 1% potassium silicate.
T_4- 2% amino acids T_5- 4% amino acids. T_6- 0.5% potassium silicate and 2% amino acids

No significant differences were recorded as a result of increasing the concentration of spraying potassium or amino acids solutions. Therefore, from an economic standpoint, it is preferable to spray potassium silicate or amino acids at a lower concentration, whatever individually or mixed.

2- Fruit quality:

A- Fruit physical characteristics:

Results in Tables (3 & 4) indicate that fruit weight, fruit dimensions and flesh percentage were significantly affected by different treatments during two studied seasons. In general, spraying amino acid at 2 or 4% as well as spraying potassium silicate at 0.5 or 1% significantly increased the previously studied traits compared to unsprayed ones (control). Moreover, potassium silicate at 5% plus amino acid at 2% was achieved higher fruit weight (15.82g) and flesh % (90.75%) and fruit length (3.70 cm as av. of the two studied seasons) compared with the other treatments and control, while the control recorded the lowest value in this respect, fruit weight (13.79 g), flesh % (87.91%) and fruit length (3.41 cm) as an av. of two studied seasons, respectively.

The recorded average fruit weight was (13.79, 15.69, 15.77, 14.57, 14.75 & 15.82 g) and flesh % (87.91, 90.64, 90.87, 90.31, 90.66 & 90.75%) and fruit length (3.41, 3.65, 3.70, 3.49, 3.51 & 3.70 cm as an av. of the two studied seasons) due to T1 to T6, respectively. Moreover, the increment percentage of fruit weight due spraying potassium silicate or amino acids compared to unsprayed one (control) attained (14.53, 15.11, 7.08, 7.66 & 15.47%), respectively.

These results showed that no significant differences were seen due to increase the concentration of spraying potassium silicate or amino acids solutions. So, from an economic standpoint it could be concluded that to spray potassium silicate or amino acids at a lower concentration.

Table (3): Effect of potassium and amino acid spraying on average fruit weight and flesh of Barhee dates during 2020 and 2021 seasons.

Charac. / Treat.	Average Fruit weight (g)			Flesh %		
	2020	2021	Mean	2020	2021	Mean
T1	12.88C	14.69C	**13.79C**	87.39B	88.42B	**87.91B**
T2	14.74A	16.63A	**15.69A**	90.18A	91.10A	**90.64A**
T3	14.65A	16.89A	**15.77A**	90.32A	91.42A	**90.87A**
T4	13.60B	15.58B	**14.59B**	89.87A	90.75A	**90.31A**
T5	13.83B	15.67B	**14.75B**	90.10A	91.21A	**90.66A**
T6	14.88A	16.75A	**15.82A**	90.28A	91.22A	**90.75A**
New LSD	**0.84**	**0.99**	**0.65**	**0.58**	**1.51**	**1.11**

Table (4): Effect of potassium and amino acid spraying on fruit length and fruit diameter of Barhee dates during 2020 and 2021 seasons.

Charac. / Treat.	Fruit length (cm)			Fruit diameter (cm)		
	2020	2021	Mean	2020	2021	Mean
T1	3.35C	3.46C	**3.41C**	2.32C	2.38C	**2.35C**
T2	3.62A	3.68A	**3.65A**	2.58A	2.63A	**2.61A**
T3	3.64A	3.75A	**3.70A**	2.60A	2.61A	**2.61A**
T4	3.45B	3.53B	**3.49B**	2.46B	2.51B	**2.49B**
T5	3.47B	3.55B	**3.51B**	2.45B	2.51B	**2.48B**
T6	3.65A	3.74A	**3.70A**	2.60A	2.65A	**2.63A**
New LSD	**0.10**	**0.10**	**0.07**	**0.07**	**0.08**	**0.05**

B- Fruit chemical characteristics:

It is clear from the results in Tables (5, 6 & 7) that spraying potassium silicate and amino acids either alone or in combinations, significantly resulted in improving fruit chemical properties, in terms of increasing T.S.S.%, sugar contents and decreasing the acidity and tannins in relative to the control treatment. As for TSS %, and sugar contents, the results in Tables (5 & 6) reveal that using foliar application of potassium silicate at 0.5% plus 2% amino acid followed by potassium silicate at 1% and 0.5% in descending order gave better results (39.08 & 33.51%), (38.81 & 33.39) and (38.83 & 33.50% as an av. of the two studied seasons) for TSS and total sugars due to T6, T2 and T3, respectively. On the other hand, control scored the lowest value in this respect (36.81 & 31.64%), respectively.

The recorded TSS was (36.81, 38.81, 38.83, 38.31, 38.46 & 39.08%) and total sugar was (31.64, 33.39, 33.50, 32.98, 33.01 & 33.51% as an av. of the two studied seasons) due to T1, T2, T3, T4, T5 and T6, respectively. Then, the corresponding increment percentage of total sugar attained (5.53, 5.88, 4.24, 4.33 & 5.91%) due to T2 to T6 compared to T1, respectively.

Moreover, no significant differences were found due to spray potassium at 0.5 or 1% whatever, alone or in combination amino acids at 2% plus 0.50%. So, from economic view, it concluded that spraying 0.5% potassium silicate alone or in combination with 2% amino acids to get best dates quality.

With regard to acidity % and tannins contents, all spraying treatments were reduced such studied traits as compared with the control, and lower values in this respect (0.124 & 0.124%) and (0.206 & 0.209% as an av. of two studied seasons) were obtained by potassium silicate at 1% (T2) or 0.5% potassium silicate plus 2% (T6), respectively. Meanwhile, control treatment gave the highest value in this respect (0.134 & 0.224% as an av. of two studied seasons)

In general, the lowest percentage of fruit chemical properties except acidity and tannins contents were found in control. On the other hand, spraying potassium silicate at 0.5 or 1% alone followed by potassium silicate at 0.5% plus 2% amino acids recorded the highest value in this respect. No significant differences were found due to spraying potassium alone or potassium plus amino acids any concentration of spraying solution. So, in general economic view, it concluded that spray potassium silicate alone or in combination amino acids at lower concentration to get high yield with good dates quality.

Table (5): Effect of potassium and amino acid spraying on TSS and total sugars of Barhee dates during 2020, 2021 and 2022 seasons.

Charac. / Treat	TSS (%)			Total sugars %		
	2020	2021	Mean	2020	2021	Mean
T1	36.50B	37.11B	**36.81B**	31.42B	31.86B	**31.64B**
T2	38.66A	38.96A	**38.81A**	33.18A	33.59A	**33.39A**
T3	38.73A	38.93A	**38.83A**	33.36A	33.63A	**33.50A**
T4	38.05A	38.56A	**38.31A**	32.78A	33.18A	**32.98A**
T5	38.22A	38.70A	**38.46A**	32.76A	33.25A	**33.01A**
T6	38.93A	39.22A	**39.08A**	33.41A	33.61A	**33.51A**
New LSD	**1.39**	**1.25**	**0.95**	**0.95**	**0.88**	**0.65**

Table (6): Effect of potassium and amino acid spraying on reducing and non-reducing sugars of Barhee dates during 2020 and 2021 seasons.

Charac. / Treat.	Reducing sugars (%)			Non-reducing sugars (%)		
	2020	2021	Mean	2020	2021	Mean
T1	23.38C	23.35C	**23.37C**	8.04B	8.51B	**8.28B**
T2	24.45A	24.52A	**24.49A**	8.73A	9.07A	**8.90A**
T3	24.53A	24.48A	**24.51A**	8.83A	9.15A	**8.99A**
T4	24.08B	24.18B	**24.13B**	8.70A	9.00A	**8.85A**
T5	23.95B	24.15B	**24.05B**	8.77A	9.10A	**8.94A**
T6	24.61A	24.43A	**24.52A**	8.80A	9.18A	**8.99A**
New LSD	**0.53**	**0.50**	**0.37**	**0.25**	**0.22**	**0.17**

Table (7): Effect of potassium and amino acid spraying on titratable acidity and tannins of Barhee dates during 2020 and 2021 seasons.

Charac. / Treat.	Titratable acidity %			Tannins (%)		
	2020	2021	Mean	2020	2021	Mean
T1	0.136A	0.131A	**0.134A**	0.228A	0.220A	**0.224A**
T2	0.128B	0.123B	**0.126B**	0.207B	0.201B	**0.204B**
T3	0.126B	0.121B	**0.124B**	0.204B	0.208B	**0.206B**
T4	0.129B	0.125B	**0.127B**	0.216B	0.206B	**0.211B**
T5	0.130B	0.125B	**0.128B**	0.216B	0.207B	**0.212B**
T6	0.126B	0.121B	**0.124B**	0.210B	0.207B	**0.209B**
New LSD	**0.005**	**0.005**	**0.004**	**0.013**	**0.012**	**0.009**

Discussion

In the present study, potassium silicate and amino acids were utilized to enhance fruit characteristics and yield of Barhee date palm. Amino acids are one of the most widely applied bio stimulants in agriculture field **[4].**

Potassium is important in the formation and function of proteins, fats carbohydrates and chlorophyll and in maintaining the balance of salts and water in plant cell **[27].** It activates many different enzymes involved in plant growth and vigor. Also, it enhanced root growth, drought and salinity resistance, sugars translocation and respiration reduction, as well as water loss as resulted regulating the opening and closing stomata. Potassium essential for photosynthesis, water and nutrient transport and plant cooling, hence, increases resistance of plants to biotic and abiotic stresses **[28, 29].** Hence, using potassium improves qualitative aspects of production such as color, taste consistency and preservation of many fruits. It showed a main role in controlling cell water content, carbohydrates biosynthesis and mobilization in plant tissues, then play a serious role in fruit retention. The increment in fruit physical characteristics may be due to the potassium application, where it plays an important role in pH stabilization, osmoregulation, enzyme, activation, protein synthesis, stomatal movement, photosynthesis, cell extension and important soluble in expanding **[7].**

The importance role of potassium fertilization on the fruiting of date palm was confirmed by the results of **[11, 13, 14, 15, 16, 18, 19].** They concluded that potassium is very effective in improving fruiting especially when applied with the optimum rate of N and P fertilizers. Spraying the potassium was very effective in improving the yield and fruit quality.

They are substances that promote plant growth, increase nutrient availability, and enhance quality attributes. Moreover, amino acids can act as precursors to produce secondary metabolites and signaling molecules in plant cell under stressed and non-stressed conditions **[4]** In this regard, several studies reported the positive effect of amino acids in improving fruit attributes and yield **[30, 31, 19].**

Conclusion

From the current study, it can be concluded that fruit yield and fruit physical and chemical characteristics were improved significantly by thrice foliar application of bunches with 0.5% potassium silicate alone or combination with 2% amino acids. These treatments were the best and the most effective treatments in enhancing yield and improving fruit quality of Barhee date palms.

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تأثير رش البوتاسيوم والأحماض الأمينية علي إنتاجية نخيل البلح البرحي

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الملخص

أجريت هذه الدراسة خلال موسمين متتاليين 2020 و 2021 بالمزرعة البحثية التابعة لمركز البحوث الزراعية – كوم أمبو – أسوان – مصر، بهدف دراسة تأثير رش سيليكات البوتاسيوم والأحماض الأمينية علي إثمار نخيل البلح البرحي حيث تم رش سيليكات البوتاسيوم بتركيز 0,5 أو 1% أو الأحماض الأمينية بتركيز 2 أو 4% بعد 4 و 7 و 10 أسابيع من التلقيح.

وقد أظهرت النتائج التالي:

- أدي الرش بسليكات البوتاسيوم أو الأحماض الأمينية في حالة فردية أو معاً زيادة معنوية في نسبة الثمار الباقية ووزن السوباطة وبالتالي وزن المحصول / نخلة مقارنة بعدم الرش (معاملة المقارنة).
- أدي الرش بالأحماض الأمينية بتركيز 2 أو 4% أو سيليكات البوتاسيوم بتركيز 0,5 أو 1% سواء في حالة فردية أو معاً زيادة معنوية في وزن وأبعاد الثمرة ونسبة اللحم. كذلك محتواها من المواد الصلبة الذائبة أو السكريات مع قلة الحموضة والتانينات مقارنة بعدم الرش.
- لم تظهر أي فروق معنوية عند استخدام سيليكات البوتاسيوم سواء فردية (0,5 أو 1%) أو خليط (0,5 + 2% أحماض) ولذا من الناحية الاقتصادية يفضل استخدام التركيز الأقل (0,5% سيليكات بوتاسيوم في الحالة الفردية).

من نتائج هذه الدراسة فإنه يوصي بأهمية رش سوباطات البلح البرحي بسيليكات البوتاسيوم بتركيز 0,5% وذلك ثلاث مرات خلال فترة نمو الثمار وذلك لانتاج محصول عال ذو خصائص ثمرية جيدة مع تقليل الآثار الضارة للإجهاد الحراري.